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National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines, Part 63, Subpart YYYY

Proposed New Subcategory:

Platform-mounted AeroDerivative stationary combustion turbines firing gas and driving compressors used for liquefaction at an LNG Export Facility that began operation prior to March 9, 2022

I. Introduction

This paper provides support for creating a separate subcategory of stationary combustion turbines to address certain unique circumstances at Cheniere's two Gulf Coast liquefied natural gas (LNG) export terminals. Based on EPA's broad statutory subcategorization authority, EPA should recognize that platform-mounted AeroDerivative refrigerant compressor turbines (RCTs) operated at LNG export facilities that utilize the ConocoPhillips *Optimized Cascade*SM (CoPOC) LNG production process represent a subcategory that was not contemplated during the development of Subpart YYYY and that there are currently no emissions standards for this subcategory. Cheniere chose this design for its LNG export facilities in part because it provides high "turndown" capability and enables maintenance practices that are important to ensuring the safety and reliability of Cheniere's facilities during the kinds of unavoidable (and often severe) weather events that are common on the Gulf Coast. However, the CoPOC design at Cheniere's LNG facilities presents unique challenges that affect the feasibility of using emission control devices that are available for use at other stationary combustion turbines.

II. EPA Has Broad Subcategorization Authority

Under Section 112(d) of the Clean Air Act, EPA has authority to distinguish "among classes, types, and sizes of sources within a category or subcategory" when it comes to setting emission or work practice standards.[1] EPA has relied on a wide range of criteria in establishing subcategories, and courts have broadly construed EPA's statutory authority to create different subcategories, explaining that EPA's exercise of its statutory authority to subcategorize is an expert determination warranting deference that can only be overcome when there is not a rational connection between the facts found and the subcategory decision.[2] As a result, the only successful challenge to a subcategory decision by EPA involved a subcategory based solely on low risk.[3]

Since EPA first established the list of source categories and subcategories of hazardous air pollutants pursuant to Clean Air Act Section 112(c)(1), EPA has regularly considered the availability or feasibility and the cost of controls when establishing source categories and subcategories based on "classes, types, and sizes of sources." In 1992, EPA noted that it may consider "process operations (including differences between batch and continuous operations),

[1] 40 U.S.C. § 7412(d).
[2] *NRDC v. EPA*, 489 F.3d 1364, 1375 (D.C. Cir. 2008).
[3] *NRDC*, 489 F.3d at 1373 (rejecting EPA's decision to create a "low-risk" subcategory).

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emissions characteristics, control device applicability and costs, safety, and opportunities for pollution prevention."[4] It made a similar statement in 1998, explaining that "In establishing subcategories, the EPA has considered factors such as air pollution control engineering differences, process operations (including differences between batch and continuous operations), emission characteristics, control device applicability, and opportunities for pollution prevention"). 63 Fed. Reg. 48,890 at 48,895 (Sept. 11, 1998).

Likewise, in the 2003 Quad Y Proposal, EPA noted that it could define a subcategory based on a number of factors including "overall facility size, emissions characteristics, processes, or air pollution control device viability."[5]

Consistent with this, EPA has stated that "The Clean Air Act allows EPA to divide source categories into subcategories when differences between given types of units lead to corresponding differences in the nature of emissions and the technical feasibility of applying emission control techniques."[6] Some examples of National Emission Standards for Hazardous Air Pollutants (NESHAPs) in which EPA created subcategories based in part on the availability, feasibility, or cost of controls include the RICE NESHAP[7] and the Industrial Commercial and Institutional Boiler NESHAP.[8]

EPA also has a history of creating subcategories based on the location of the emission units. For example, in 2013 EPA amended the NESHAP for reciprocating internal combustion engines (RICE) to create a new subcategory for existing RICE located in "sparsely populated areas" because

> [e]ngines located in remote areas that are not close to significant human activity may be difficult to access, may not have electricity or communications, and may be unmanned most of the time. The costs of the emission controls, testing, and continuous monitoring requirements may be unreasonable when compared to the HAP emission reductions that would be achieved, considering that the engines are in sparsely populated areas.[9]

Similarly, EPA created a separate stationary combustion turbine subcategory for turbines located on the North Slope of Alaska "based on concerns about the applicability of emission control technology."[10]

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[4] *See* 57 Fed. Reg. 31,576, 31,580 (July 16, 1992).
[5] 68 Fed. Reg. 1888, at 1908 (Jan. 14, 2003) (emphasis added).
[6] 68 Fed. Reg. 1660, at 1670 (Jan. 13, 2003).
[7] 78 Fed. Reg. 6674, at 6675-76 (Jan. 30, 2013).
[8] 76 Fed. Reg. 15,554, at 15,572 (Mar. 21, 2011).
[9] *See also* 78 Fed. Reg. at 6682.
[10] 69 Fed. Reg. 10,512, at 10,532 (Mar. 5, 2004); *see also id.* ("Stationary combustion turbines located on the North Slope of Alaska have been identified as a subcategory due to operation limitations and uncertainties regarding the application of controls to these units.").

III. Overview Of Cheniere's Liquefaction Process and Cheniere's Refrigerant Compressor Turbines

Through the CoPOC process, dry gas is fed to refrigeration systems at "LNG production trains," where it is liquefied through a combination of heat exchangers and pressure reduction processes that utilize propane, ethylene, and methane refrigerants. The LNG product is then pumped to LNG storage tanks for export.

Cheniere uses the CoPOC process at all nine of its LNG production trains— six at the Sabine Pass, Louisiana facility (SPL) and three at the Corpus Christi, Texas facility (CCL). Each of Cheniere's nine liquefaction trains use six LM2500+ G4 gas turbine-driven RCTs, each rated at 34.7 megawatts (MW). Thus, Cheniere has a total of fifty-four (54) RCTs, collectively rated at almost 1.9 gigawatts (GW), in operation at any one time. As discussed below, instead of servicing and maintaining the RCTs in place, it regularly swaps them out for maintenance, so it owns and employs another 33 RCTs as part of its maintenance program. Thus, Cheniere owns and operates a total of 87 RCTs at its two LNG export facilities.

All the RCTs at Cheniere's LNG facilities are "AeroDerivative," which means the core engine is a General Electric CF6 flight engine that is used on most of the commercial aircraft flying today. Although AeroDerivative turbines are also used at other stationary sources, they first operated at an LNG facility (the Darwin LNG facility in Australia) in 2006. They are light weight and approximately 40 percent more efficient than Frame 5 or Frame 7 turbines, which are the other turbines commonly used in the LNG industry. Based on publicly available information, we believe that none of the other LNG export facilities currently operating in the U.S. use the CoPOC process or AeroDerivative combustion turbines to drive refrigeration compressors.

The design of Cheniere's LNG terminals is complex, with the turbines installed on pedestals positioned approximately 60 feet from base elevation, approximately 33 feet from ground level and clustered closely together for design efficiency. This elevated, compact design is integral to the LNG production process, and (as discussed further below) was selected because of its high "turndown" capability and high maintainability.

The turbine design drives the configuration of the surrounding liquefaction facility. Traditional "Frame" turbines must be spaced out to provide additional room to accommodate equipment, personnel access and replacement parts to allow the turbines to be maintained in place. This design configuration creates adequate space to add exhaust controls on Frame turbines, while the spacing and elevated location of Cheniere's AeroDerivative turbines makes installation of exhaust controls much more challenging.

IV. The Design Implemented By Cheniere Was Necessary Based On Specific Circumstances

Because of their location, both SPL and CCL are subject to natural events, such as high winds, high seas, fog, tropical storms, and hurricanes that at times may disrupt shipping from transiting their respective channels. The challenges of maintaining high rates of efficiency and reliability at these locations drove Cheniere's selection of the CoPOC design because of its high "turndown" capability and high maintainability relative to other designs.

A. High "Turndown" Capability

Cheniere's LNG terminals operate 24 hours per day, constantly producing LNG that is stored in LNG tanks until loaded onto a LNG tanker for export. If there are disruptions on the shipping channel that prevent an LNG tanker from loading LNG and the LNG storage tanks are approaching their "tops", Cheniere may need to ramp down production. Because the CoPOC design has the ability to turndown to 10 percent of normal production levels without shutting down completely, starts and stops of turbines and associated maintenance, startup, or shutdown (MSS) emissions can be avoided or minimized when the channels close due to natural events.

This high turndown capability has multiple advantages over other liquefaction designs. First, it allows the facilities to avoid the significant flaring—approximately 24 hours—associated with the necessary cooldown process after a full process shutdown. Second, it minimizes the number of startup and shutdown sequences, increasing the reliability of equipment such as turbines, pumps, fans, and valves. Together, this results in lower air emissions. Finally, it allows the temperatures in the exchangers to remain constant, which supports mechanical integrity and reduces process safety risks, by reducing the number of thermal cycles of the exchangers.

The other type of large-scale LNG plant currently in operation utilizes a design known as C3MR. These plants have large cryogenic heat exchangers. At these plants, production can be ramped back only to about 60 percent of normal production before a complete shutdown is required. Cheniere's CoPOC design, with its ability to maintain operations at only 10 percent of normal production, provides significantly greater flexibility when responding to the natural events that at times can disrupt shipping and loading of LNG. This design thus allows Cheniere to minimize flaring, reduce the frequency of startups and shutdowns, associated MSS emissions and maintain constant temperature in the heat exchangers, thereby increasing equipment reliability, supporting mechanical integrity of critical equipment and reducing the overall risk profile of operations to the public and environment.

B. High Maintainability

The occurrence of these natural events along the Gulf Coast were a consideration that drove Cheniere's need for turbines designed for flexible maintenance. Cheniere chose AeroDerivative turbines in part because they can be changed out and maintained off-site. In contrast, "Frame" turbines such as the Frame 5s or Frame 7s are larger and not designed for modular change out, which means that they are normally maintained in place. Cheniere can modularly replace a RCT in as little as 25 hours. In contrast, the type of Frame turbine used with the C3MR design may be offline for combustion inspection at 12,000 hours for 7 to 10 days, hot gas path inspection at 24,000 hours for 14 days and at the "major inspection" point at 48,000 hours for 27 days. It can take approximately 5 to 10 days to swap out a Frame turbine. Part availability can also be a challenge for frame turbines, which could extend outage timelines. This ability to rapidly replace turbines reduces "downtime", which allows sections of the plant to remain in a cold state, thereby reducing thermal cycles of critical equipment leading to improved mechanical integrity and reduced process safety risk.

The parallel refrigeration strings inherent to the CoPOC process also allows on-line maintenance because one refrigeration string can stay online and maintain process temperatures while the other string undergoes maintenance. This reduces MSS emissions associated with a full process shutdown and reduces thermal cycles of critical equipment.

The advantages of being able to swap out RCTs at Cheniere's Gulf Coast facilities is best illustrated by an example. If export operations are curtailed because an LNG carrier is stuck off the coast waiting for the channel to reopen, Cheniere is able to take advantage of the maintenance window that is created. Because production can be turned down to as low as 10 percent of normal levels, one or more RCTs can be taken offline without the need for a shutdown. Because Cheniere can swap out an RCT in as little as 25 hours, it can take advantage of the weather conditions to swap out an RCT for maintenance, without having any additional impact on operations.

Clustering of the AeroDerivative turbines is desired to increase thermal and process efficiency. Keeping the equipment closely located reduces thermal losses and pressure drop associated with long runs of piping and reductions due to gravitational losses (changes due to elevation), resulting in more efficient LNG production.

The AeroDerivative turbines are located on elevated platforms to allow for a more compact design and construction. This equipment arrangement allows any condensables in the process streams to "fall out" in associated knock-out drums. This prevents any condensed liquids from entering the compressors. This enhances mechanical reliability and integrity. This configuration is inherent to the CoPOC process design and is an example of robust safety design.

Additionally, in the event a rotor needs to be replaced, the top half of the casing likely needs to be removed to perform the replacement. If the compressors are located on the ground, the only place for the suction and discharge piping to attach to the compressor is the top half of the compressor casing. In that design case all the suction and discharge piping must be removed before the compressor casing can be accessed and removed to replace the rotor. The flanges on suction and discharge piping are some of the largest in the facility and have delicate gaskets that can be difficult to handle. The piping alignment and compressor alignment, which is normally only done once, will likely need to be done every time the compressor top casing is removed. All these factors could increase the maintenance timeline by approximately 10-12 days for compressors and turbines located on the ground. Thus, the compressors and turbines are elevated to provide better maintainability.

V. Feasibility of Pollution Control Devices

Due to the design of the SPL and CCL facilities and the configuration of the 54 RCTs, installation of oxidation catalysts presents significant engineering challenges. Specifically, there are structural concerns, as stack-based controls would require significant structural and infrastructure retrofits due to the platform mounted turbines design. Due to the location of Cheniere's Gulf Coast facilities and regulatory mandated design requirements for wind resistant structures, it may not be feasible to retrofit the existing equipment with an oxidation catalyst. A feasibility analysis would need to address spacing, process conditions, hazard modeling, mechanical integrity, process safety and catalyst performance. If it is determined that installation of oxidation catalysts is possible, it is unlikely that it could be accomplished without significant reconstruction requirements that may have a lasting impact on process conditions. Specifically, the addition of an oxidation catalyst is likely to result in increased backpressure, which in turn could introduce additional safety and operational risks. Engineering and design to evaluate the feasibility of installing oxidation catalysts could take several years, not including the time associated with regulatory approval.

VI. Cheniere's LNG Export Terminals Are Subject To The Oversight Of FERC and PHMSA

The Federal Energy Regulatory Commission's (FERC's) authority over LNG facilities comes from the Natural Gas Act (15 U.S.C. §§ 717b and 717b-1). Current FERC Orders authorizing construction and operation require annual inspections and Semi-Annual Reports to FERC regarding any modifications to the facility. FERC's position is that "any changes to an LNG facility or its design, whether occurring before or after the facility has gone into operation, require Commission authorization before they are implemented." 18 C.F.R. § 153.5.

The Pipeline and Hazardous Materials Safety Administration's (PHMSA's). authority over LNG facilities stems from the Pipeline Safety Act (49 U.S.C. §§ 60101, et seq.), which PHMSA implements through safety regulations at 49 C.F.R. Part 193. These regulations include a requirement to notify PHMSA of modifications exceeding $10 million, which any redesign and/or rebuild would exceed. In addition, FERC and PHMSA together evaluate the adherence of an LNG facility's to PHMSA's safety regulations during initial federal permitting, but the obligation to comply with Part 193 is ongoing. For example, PHMSA establishes "exclusion zones," which are areas surrounding an LNG facility in which the operator legally controls all activities to protect the public from the potential adverse effects of thermal radiation heat flux levels and flammable vapor-gas dispersion concentrations for as long as the facility is in operation. The addition of air pollution controls could impact one or both, which could necessitate PHMSA review.

FERC's authority is extremely broad and many other changes at LNG facilities may prompt review and/or approval by one or both agencies. Changes that might trigger FERC review include but are not limited to:

- Changes to basic process design
- Changes to structures, including those that could affect dispersion modeling or flood event modeling
- Changes that could affect process safety
- Changes or issues that result in elevated risk work activity
- Impacts to existing fire and gas detection and mitigation systems

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- Impacts that could influence the application of industry standards
- Changes that influence facility siting
- Significant changes to process design
- Addition of new structures or equipment

For example, under the 2012 Order that authorized construction of SPL, Cheniere was required to submit for review and written approval information demonstrating that the proposed emission control systems for acid gas removal would not affect the siting analysis required by PHMSA that was included in the application and supplements. The addition of an oxidation catalyst would meet several of the above examples necessitating a review and approval process.

Any structural changes at SPL or CCL to enable the installation of pollution control devices are likely to be subject to the oversight of the FERC and PHMSA. The requirement to consult with and potentially engage in a formal process with PHMSA and FERC could significantly delay the installation of any pollution control device. Based on Cheniere's experience with both agencies, Cheniere believes that agency engagement could range from informal coordination (which alone can take significant time and resources) up to the requirement to submit a formal amendment to the underlying FERC order, requiring Commission approval. Additionally, changes to either facility would need to be reviewed by PHMSA, potentially requiring the agency to issue a Letter of Determination that the changes contemplated are still compliant with 49 CFR 193 siting requirements. If necessary, consultation or formal approvals require extensive documentation to the agencies, a process that could take up to two years.

VII. EPA Should Use Its Broad Subcategorization Authority To Establish A New Stationary Combustion Turbine Subcategory

Several factors that EPA has historically considered when making decisions about subcategories justify creating a separate subcategory for the platform-mounted RCTs at SPL and CCL.[11] These facilities are the only sources in the United States using platform-elevated AeroDerivative turbines to drive compressors at LNG export facilities. We are not aware of any other facility in the U.S.—LNG or otherwise— that uses turbines in this specific type of manufacturing process, and EPA has repeatedly recognized that different "manufacturing processes are an acceptable basis that Congress intended for distinguishing between classes or types of sources."[12]

EPA's past practices of creating subcategories based on a source's location and the technical feasibility of controls clearly support this new subcategory.[13] Previously, EPA has created

[11] 68 Fed. Reg. at 1908.

[12] 82 Fed. Reg. 60,873, at 60,881 (Dec. 26, 2017); *see also* 68 Fed. Reg. 70,904, at 70,918 (Dec. 19, 2003) ("It is our general policy to subcategorize when there are technical distinctions among classes, types, or sizes of sources, and manufacturing processes of sources, that would impact setting an appropriate emission limit <u>even when creating the subcategories leads to some with a small number of sources</u>.") (emphasis added).

[13] *See* 78 Fed. Reg. at 6682; 69 Fed. Reg. at 10,532; *see also* 76 Fed. Reg. 15,554, at 15,575 (Mar. 21, 2011) (Through EPA's discretion to develop subcategories, "we are able to define subsets of similar emission sources within a source category if differences in … technical feasibility of applying emission control techniques … exist within the source category" and such a decision can be based on "[t]he design, operating, and emissions information that EPA reviewed during" the rulemaking.).

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subcategories for engines in "sparsely populated locations" and for turbines situated on the North Slope of Alaska because the location impacts the source's ability to apply pollution controls or the cost-effectiveness of them. The same is true of the turbines at SPL and CCL given that they are located in tight clusters on elevated platforms. And, as described in detail above, significant case-by-case design and engineering work would be required to determine the feasibility of retrofitting controls. If feasible, retrofitting would at the very least require major infrastructure improvements, including structural modifications to existing turbine pedestals, installation of additional pedestals to support the control equipment, the rerouting of turbine exhaust, and the installation of supplementary equipment necessary to ensure effective operation of the control equipment. These infrastructure improvements would likely necessitate extensive coordination with other Federal agencies, namely PHMSA and FERC.

Finally, EPA has created new source subcategories when presented with information that shows that a type of source was not contemplated by the original rulemaking. In 2019, SA Exploration, Inc. wrote to EPA regarding the applicability of emission standards for Commercial and Institutional Solid Waste Incineration Units (NSPS CCCC) and for Other Solid Waste Incineration Units (NSPS EEEE) to certain portable incinerators used at various exploration camps in Alaska. After reviewing information provided by the company, EPA concluded that there are currently no emissions standards that apply to these particular units, explaining that

> [a]fter further review of the CISWI subcategories, we recognize that this type of unit may represent a different subcategory that was not contemplated during the development of CISWI rule. In addition, we do not have any emission data to evaluate this subcategory.[14]

The same is true for refrigeration combustion turbines used at LNG export facilities. Because no such facilities existed or were even being considered in the U.S. when EPA developed Quad Y, they were certainly not contemplated during the development of the rule.

[14] EPA Letter to SA Exploration, Inc. at 2 re: Regulatory Interpretation of Incinerator Regulations for Small, Portable Incinerator (Mar. 1, 2019).